Systematic Approach for Uncertainty Delta E Data for Composites Panel Coating Analysis

Elmi Abu Bakar, W. A. F. W. Othman and A. R. Othman

Abstract In general, Aerospace industry has been developing significantly throughout the economy as demands on technology in advanced transportation is increasing. Furthermore, as a multi-billion dollar industry, the efforts is needed to sustain high quality of products for safety, minimizing waste during process and increase in a pace of manufacturing. Therefore, Six Sigma tool which is DMAIC approach is chosen to presents a case of an efficient and systematic method of improvement cycle 'Define, Measure, Analyze, Improve and Control' to define and analysis defect, hence to improve the quality of production in aerospace industry. In this study, the focus is done by studying how the implementation of Six Sigma on an aerospace company especially to solve the problem of uncertainty condition of Delta-E for Panel Coating. By using the DMAIC approaches, defects and problems that arise in the production line of the company are being sorted out and solved. Trials and experiments were also conducted on the company's production line and the data is being collected for analysis and study purpose. Through observation and data taken from above problem, analyzed results perform remarkable solution to be applied by Aerospace Industry.

Keywords DMAIC · Defects · Production line

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1 Introduction

Nowadays, in growing competitive market environment, customers or stakeholders are always demanding on a quality products and services. Therefore, quality is considered as one of the most remarkable performance that measures and influences the manufacturer's competitiveness. In this circumstances, quality improvement activities have become a part of the business culture and the way of life. A multi-billion dollar business industry need to sustain low expenditure with good quality products and minimizing the waste. Furthermore, industry also need a to increase the pace of manufacturing in order to accomplish and also maintain the competition in the market.

Throughout the past few decades, Six Sigma is defined as a practice to improve business processes by not only restraining oneself to quality control purposes. Moreover, it's have been enormously implemented by global industries and achieved remarkable enhancements in their stakeholders' satisfaction, consistency and performance of products or services. Moreover, the Six Sigma is a collegiate assortment of many well-established tools and techniques. One of the main advantage from a Six Sigma program is the removal of partiality in decision-making by creating a scheme where everyone in the organization collects, analyses, and displays data in working area as reference.

DMAIC approach has been widely used in manufacturing areas and industries but not regularly has been applied in aerospace manufacturing line process. An experiment has been conducted in Aerospace Company located in Selangor. In manufacturing line process, in order to improve the current process problem, the first stage of DMAIC by defining a problem, measure important data, analysis the problem, suggest improvements and control the improvements for their future success. The early stage of defining a problems and measuring data from manufacturing line process is very important for defects' validation purpose. From the data measured, analysis can be made and the root cause can be obtained. Hence, steps for improvement can be built and controlled later.

Six Sigma is a business performance improvement strategy that aims to reduce the number of mistakes/defects to as low as 3.4 occasions per million opportunities. Sigma is a measure of "variation about the average" in a process which could be in manufacturing or service industry [1]. Linderman et al. defined Sig Sigma as an organized and systematic method for strategic process enhancement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in through the standard has been provided by main Aerospace industry customer [2]. Six Sigma was accepted as an effective quality management tool for driving and achieving changes within an organization and it is a continuous improvement process focusing on the customer requirements, process design, planning and association together with demanding, analytical and statistical tools [3]. Based on the nature of the process, the selection of tools may be varied. Different tools can be used in different phases of the implementation process. The five steps of DMAIC method often called as process improvement

methodology is designed to allow for flexibility and iterative work. Assumption or hypotheses as to the root cause of the problem may be invalidated, requiring the project team to revisit them and change or to discover alternative possibilities. Over the years, elevated safety principles are pursued by the aerospace industry to improve the composite products in order to develop the processes involved. Furthermore, the developments of the method in order to shape up intricate products to the great safety standards are leaded by the aerospace industries. The utilization of the tools that are currently being practiced by the modern enterprises of business such as Total Quality Management (TQM) and Six Sigma have currently been tested as well as espoused predominantly in the aerospace industry. There are plenty of case studies that have been provided on the implementation of Six Sigma principles in the aerospace industries [4]. Six Sigma is used widely in the aerospace companies for the enhancement of design, business, supply chain procedures and also manufacturing. This paper discuss on the implementation of DMAIC approach in Aerospace industries.

2 Methodology

This study is conducted at one of Aerospace Industry located in Selangor, Malaysia. The Aerospace Company in Malaysia that focused on manufacturing and responsible for Sub-Assembly of Wing's panels before shipping to main industry that assembly the overall aircraft component. One of the general issues that arise in manufacturing line process is focused and studied to apply the DMAIC approach. The flow of manufacturing line process is deliberate before the main issue is being focused. The methodology of this research is illustrated in Fig. 1.

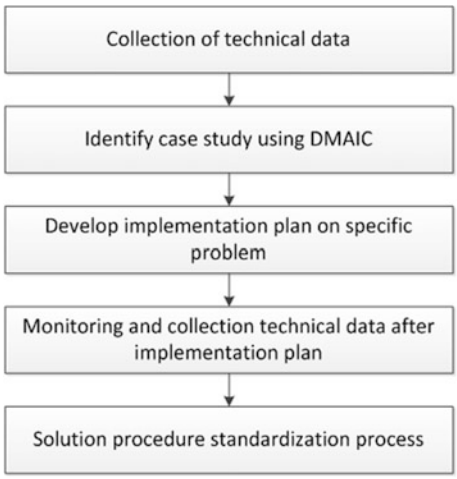

Fig. 1 The methodology illustration

2.1 Case Study of Delta E for Panel Coating Analysis

Delta E is defined as the difference between two colors in the format of "L*a*b*" color space. As the values determined are based on a mathematical formula, it is important that the type of color formula is taken into account when comparing the values. In Color Verifier alone, there are three different formulas to choose from, each producing different results. The CIE L*a*b* formula used in the proofing market calculates the Euclidian distance, the distance between two points in a three-dimensional color space. The actual position of the points themselves is irrelevant. Figure 2 shows the color space of related Delta E information and related equation in Eq. (1) below.

However, the human eye is more sensitive to some areas of color and less sensitive to others, a fact that the formula does not take into account. To avoid the uncertainty judgement reading from the human eye, further color formulas have been developed. Colors in a highly saturated area are assigned less importance during the evaluation than colors along the grey axis, which is where the human eye is most sensitive.

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \tag{1}$$

To say that a Delta E value of 1 is visible to the untrained eye is, therefore, true for the grey axis which not apply for the highly saturated area. Nevertheless, the CIE L*a*b* color formula is still used by the proofing market. However, it is perfectly acceptable to use, for example, CMC or CIE 94 in the production market to check the stability of the output device [5].

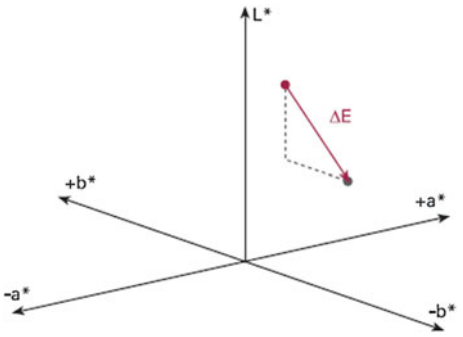

Fig. 2 Delta E

2.2 Identify Case Study Using DMAIC

Specific problems that arise in the company are focused to implement through this approach as the case studies to be done. Frequent issues and problems that arise are focused and studied. General process flow and work break structure (WBS) flow of the process is taken into account. Each process of sub-assembly process need to be monitored and observed before process of collecting data can be conducted. Then, the DMAIC approach can be applied. The general flow of DMAIC should be brainstorm as Fig. 3 shown.

2.3 Solution Procedure Standardization Process

The next step is proceed once the solution has been decided, the procedure must be standardized and control of the implement plan for sustainability to achieve the targets. Such new procedure must be carried out as standard and usual procedure by the operators. In Fig. 4 represent the overall flow of stages of process.

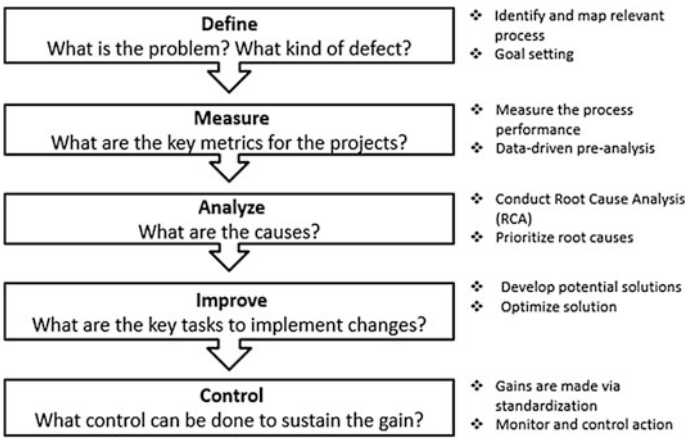

Fig. 3 Illustration of DMAIC approach

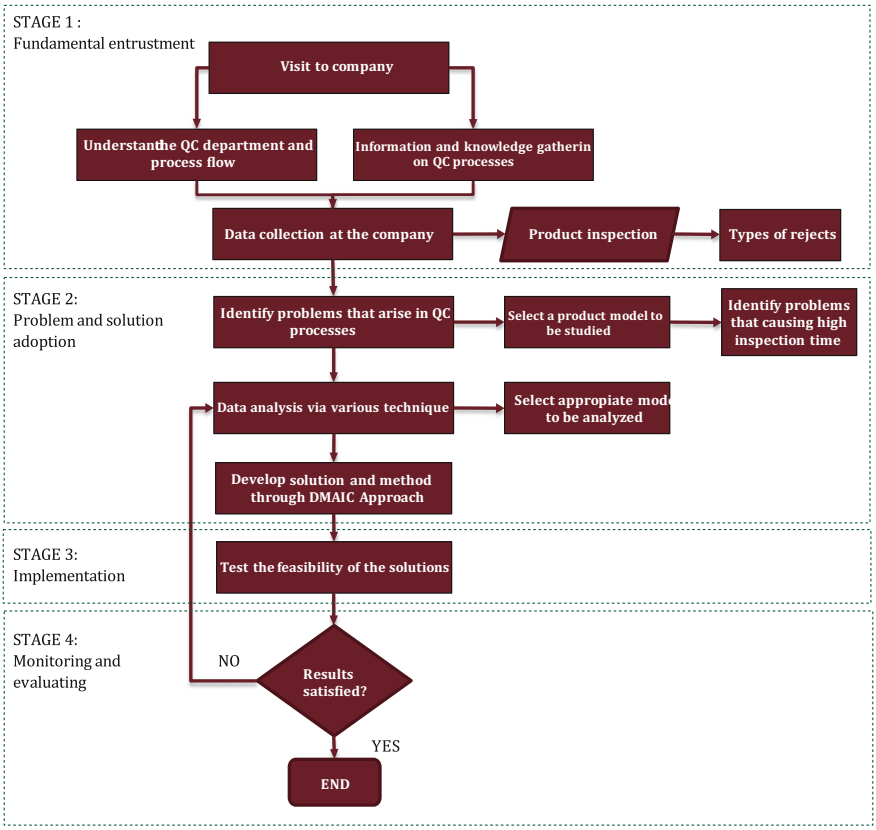

Fig. 4 Overall process flow

3 Results and Discussion

3.1 Trial One: Identify Current Observation on Paint Batch #108

Trial one with flow chart as shown in Fig. 5. The trial one is an observation on current activity of painter or Paint Shop's operator. The trial is conducted on two sets of Trailing Edge panels which sum up to 44 panels as each set of Trailing Edge have 22 parts (11 parts for PORT and 11 parts for STBD). Paint that was used for the Top Coat of the panels is from the new Paint Batch #108. Maximum Time between Coating (MTBC) is flash off time for the panels. During, paint coating process or surface coating, the panels will be left for several periods before the painter begin to do the second coating, this is because to maintain the paint consistency and coating quality. Hence, we want to study whether the MTBC will affect the reading of Delta E values and results. For trial one, the MTBC is 70 min.

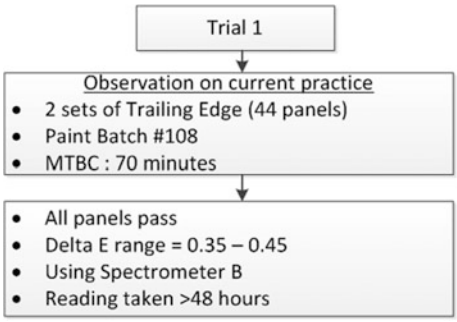

Fig. 5 Illustration of trial 1

Based on the current trial activity, all panels passed the requirement of the Airbus which is to maintain the Delta E values less than 0.50. The reading of Delta E values is taken after 48 h when the Top Coat of the panels are done. 3 panels in the range 0.30–0.39 and 16 panels in the range 0.40–0.49 but the highest Delta E value obtained is 0.45. From the trial, the current practice shows positive results, but MTBC of 70 min is quite time consuming as Paint Shop has limited quantity of Paint Booth to do the surface coating. The result as shows in Fig. 6.

3.2 *Trial 2: Identify Current Observation on Paint Batch #65*

The second trial is done by using the suspected problem Paint Batch #65 with MTBC of 30 min. The second trial is conducted on one set of Trailing Edge panels, which contain 22 parts. The flow as shown in Fig. 7.

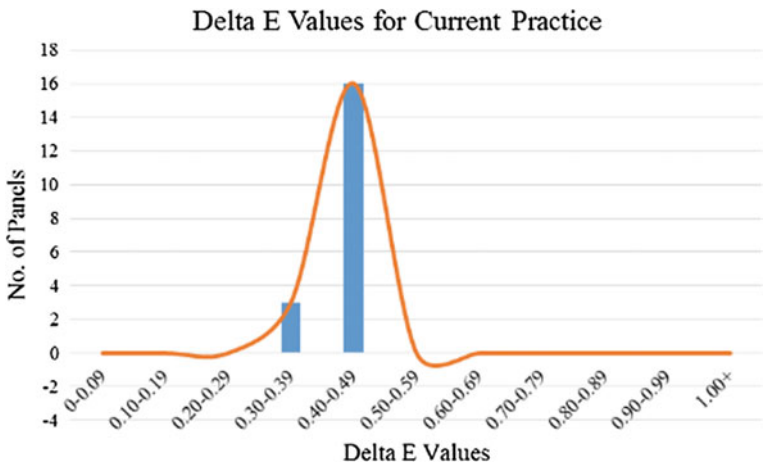

Fig. 6 Graph of Delta E values for current practice

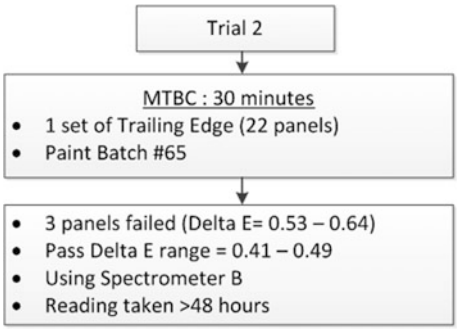

Fig. 7 Illustration of trial 2

Based on the second trial, 19 panels passed and the other 3 panels failed. The 3 panels are in a range of 0.53–0.64. The Delta E readings are taken 48 h later after the Top Coat of the panels by using Spectrometer from Paint Shop which labelled as Spectrometer B. The result shows in Fig. 8.

As result is shows in Fig. 9, for Paint Batch #65, panels are majorly in a range of 0.40–0.48, 1 panel in a range of 0.30–0.39 and the other two panels in a range of 0.50–0.59 for the Delta E values. However, 1 panel in the range of 0.50–0.59 is passed the Delta E requirement with a reading of 0.50, hence only 1 panel is failed with a reading of 0.52. While as for Paint Batch #108, all the panel passed the Delta E requirement with range of 0.17–0.38; most of the panels in a range of 0.20–0.29, 4 panels in a range of 0.30–0.39 while the other 2 panels are in a range 0.10–0.19 and 0.40–0.49 each. In conclusion, as from the results analysis of the forth trial, the Spectrometer A and Spectrometer B gave inconsistent reading as shown in the graphs above.

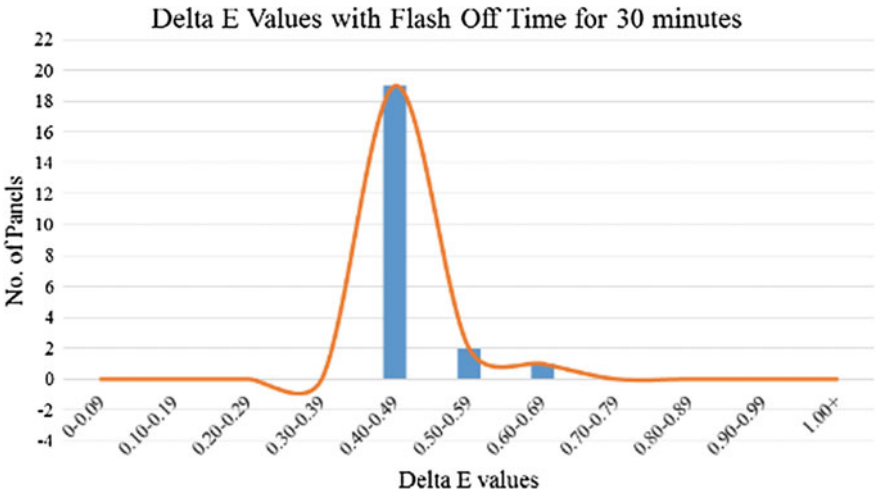

Fig. 8 Graph of Delta E values with flash off time of 30 min

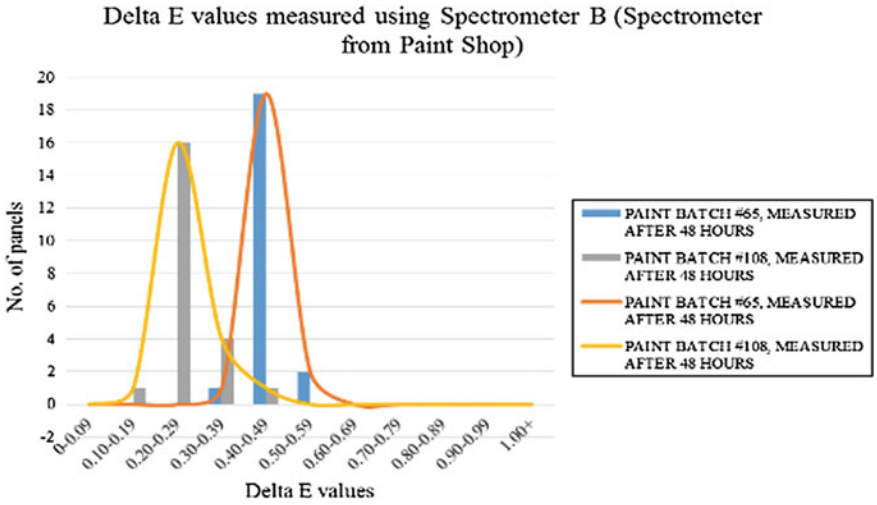

Fig. 9 Graph of Delta E values measured by using spectrometer B

The validation process is conducted thru each trail by comparing the current practicing method and DMAIC approach method that has been mentioned in above figure in the content.

4 Conclusion

This paper proves the practicality of using DMAIC approach in solving problem that usually arise in production line which gave affect to the time consuming and production of products. This study has been carried out at the two department of the company which are Paint Shop department and Final Assembly department with in consonance with the Quality Control of the departments. The problem of uncertainty condition of data reading of Delta E values for the panels doesn't meet the requirement which exceed the maximum value of Delta E. As the results, the panels cannot be sent to the Outbound (Logistic) and cannot be sent to the customer, which failed to fulfil the demand per week of production. By introducing the defining problem root cause using DMAIC tool and apply trial of 48 h for two batch #108 and #65, we can further understand reading of Delta E problem can be improved.

Hence, the general process of the panels is being studied and the Paint Shop department is the second department that being focused at. The manufacturing line process in the Paint Shop department is being analyses and several processes that affecting the Delta E values is being highlighted. Using the correct method in problem solving is also vital. This was demonstrated in this paper where this project was carried in proper steps so that the root cause can be figured out. A detailed

process flow was developed in advance and phases were created to make sure that the project can be carried out chronologically. Detailed planning of the project will aid in problem identifying and problem solving tasks.

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